

1 initial prestrain. The optical fiber or fibers 12 on the top
2 bear no weight and actually are strained less than their initial
3 prestrain as the mass 16 moves off axis downward.

4 As can be seen from the foregoing description, as the
5 device 10 rolls or pitches, the weight of the mass 16 will be
6 directly borne by different combinations of the optical fibers
7 12. This leads to a different tension in each of the fibers 12.

8 A fiber optic Bragg grating 18 is written into the core of
9 each optical fiber 12. The changing tension in each optical
10 fiber 12 results in a wavelength shift of the reflectivity peak
11 of the Bragg grating 18. Such a wavelength shift may then be
12 measured by a variety of means already disclosed in the
13 technical literature. For example, the measuring means may
14 utilize a broadband light source such as an Erbium doped
15 spontaneous emission source to illuminate the grating 18. The
16 reflection is analyzed with a spectrum analyzer to determine the
17 reflection peak wavelength. In another type of measuring means,
18 a scanning single wavelength laser is used. The reflection
19 versus the sun time is analyzed to determine the reflection peak
20 wavelength. The difference in wavelength shift determines the
21 difference in tension. The difference in tension between the
22 optical fibers 12 allows direct calculation of the local
23 direction of the gravitational field relative to the optical
24 fibers 12 and the cage 14.

1 The gap 20 between the sides of the suspended mass 16 and
2 the cage 14 is small so that the cage 14 limits the motion of
3 the mass 16 in shock or high acceleration and limits the maximum
4 tension seen by any optical fiber 12. The exact dimension of
5 the gap 20 depends on the mass of the mass 16, the diameters of
6 the optical fibers 12, and the number of optical fibers 12. The
7 gap 20 must be large enough to accommodate the movement of the
8 mass 16 away from the center as the device 10 rolls with some
9 room to spare.

10 Because the gratings 18 reflect at a distinct wavelength,
11 multiple sensors may be placed on the same optical fiber 12 with
12 gratings 18 placed at different wavelengths. A plurality of
13 gratings 18 comprising a single sensing device may be placed on
14 separate optical fibers.

15 Referring now to FIG. 4, while it is preferred to use a
16 plurality of optical fibers 12 in the sensor 10, it is possible
17 to replace the plurality of optical fibers 12 by a single
18 optical fiber 12' having a serpentine configuration in which
19 each of the legs 30, 32, and 34 of the optical fiber 12' has a
20 grating 18 incorporated therein.

21 In yet another alternative embodiment, the optic Bragg
22 gratings 18 may be replaced by fiber optic Bragg grating laser
23 sensors such as those described in U.S. Patent No. 5,513,913.
24 These are built into the optical fibers of the sensing device

1 10. Changes in the tension in each optical fiber 12 changes the
2 wavelength of the light emitted by each laser.

3 The device of the present invention offers several new and
4 distinct advantages. First, the sensing device 10 comprises a
5 means for fiber optic sensing of roll or pitch. Further, the
6 sensing device 10 of the present invention is simple and
7 potentially inexpensive. Still further, the sensing device 10
8 may be multiplexed with many other such sensors on a single
9 optical fiber.

10 It should be noted that the sensing device of the present
11 invention may use a wide number of optical fibers 12. It is
12 preferred that at least three optical fibers 12 are used in the
13 sensing device.

14 It should also be noted the shape of the mass 16 may vary
15 from that shown in the drawings. In such a situation, the
16 optical fibers 12 may just enclose the mass 16 as shown or may
17 be affixed to the mass 16.

18 The sensing device 10 of the present invention may be
19 oriented into a towed array in different ways to function as
20 either a roll or pitch sensor. Since the only deformable
21 structures in the sensing device 10 are the optical fibers 12,
22 sensitivity of the sensing device is maximized.

23 The sensing device 10 of the present invention may be used
24 in other applications requiring a roll or pitch sensor such as a